



**ERRATUM**

**SPECIFICATION No. 498,281.**

In the heading on page 1, *for* "No.  
" 54182/37." *read* "No. 24182/37."

THE PATENT OFFICE,  
*February 2nd, 1939.*

2 - FEB. 1939

## PATENT SPECIFICATION

Application Date: May 4, 1937. No. 7370/38.  
(Divided out of Application No. 7601/37).

" " Aug. 27, 1937. No. 23523/37.

" " Sept. 4, 1937. No. 54182/37.

One Complete Specification Left: March 16, 1938.

(Under Section 16 of the Patents and Designs Acts, 1907 to 1932.)

Specification Accepted: Jan. 4, 1939.

498,281



### PROVISIONAL SPECIFICATION

No. 7370 A.D. 1938.

#### Improvements in Built-up Structural Members

I, GEOFFREY MURRAY BOYD, of 11, Burwood Avenue, Hayes, Kent, a British subject, do hereby declare the nature of this invention to be as follows:—

6 This invention relates to steel constructional members and has for an object the improvement of the moment of inertia of standard joists, for example, channel or T-section members, without materially increasing their weight.

10 The invention includes cutting the web of the member in a series of serrations, teeth, lugs or the like, and subsequently welding the pieces together after they have been re-arranged so that the depth from flange to flange of the completed member exceeds the depth of the original member.

15 The invention also includes cutting the web of the member in a series of rectangular or angular serrations, teeth, lugs, or the like, and subsequently welding the equal and equally spaced pieces together after the two pieces have been moved one pitch relative to one another so that the depth from flange to flange of the completed member exceeds the original depth by the depth of the individual serrations, teeth, lugs, or the like.

The invention also includes, in the method of either of the two preceding paragraphs, cutting the web by means of the oxy-acetylene flame: and/or cutting it in a line symmetrical about a straight line along the middle of the web: and/or cutting it so that the outstanding lugs, serrations, teeth, or the like of the pieces into which the member is cut are substantially the shape of a regular hexagon halved by a longest diameter: and/or cutting it so that changes in direction of the cutting line are not accompanied by sharp angles; and/or cutting it with periodic straight sections parallel to and alternately on each side of a common line, and welding the pieces together after re-arrangement along the straight sections of the outstanding lugs, serrations, teeth or the like of each piece; and/or reversing one of the pieces before welding together; and/or cutting the web so that upon reversing one of said pieces, and welding together, the ends of the pieces coincide; and/or in which the depth of the member is increased by half.

Dated this 8th day of March, 1938.

G. M. BOYD.

### PROVISIONAL SPECIFICATION

No. 23523 A.D. 1937.

#### Improvements in Lightened Plate Diaphragms, for Constructional Engineering or like purposes

55 I, GEOFFREY MURRAY BOYD, of 11, Burwood Avenue, Hayes, Kent, of British Nationality, do hereby declare the nature of this invention to be as follows:—

60 The invention is concerned with lightened metal diaphragms, and has for its object the production of these diaphragms from plain strips, or sheets of metal, wide or narrow according to circumstances, without the loss of material by waste.

65 Usually a plate diaphragm is lightened by cutting holes in it, the material being

ordered of the full length and breadth required to be occupied, and the holes being cut in the metal by the oxy-acetylene flame, by drilling a sequence of closely-spaced holes, or, more usually, by the use of a large punching machine.

In each case the material cut out is scrap, while the user is involved in the purchase and handling of a larger plate than he requires, apart altogether from the cost of marking out and cutting the holes. Further, it is rarely that as much

[Price 1/-]

material is removed as could be spared from the point of view of strength, as it is not practical to have a wide range of punches, so that generally use must be made of a few standard sizes of punch.

The invention provides a simpler solution, and one practically obviating waste. It consists in first cutting the plate into two pieces by means of an angularly sinuous cut, the sinuosities being preferably symmetrical about a chosen axis, forming serrations or castellations of rectangular or preferably angular or polygonal form, and of carefully chosen size and spacing. The two pieces are then separated, and re-joined to each other, or to other similarly castellated pieces, in

such a way that the crests of the castellations in the adjacent pieces are in contact and joined together, preferably by welding. The troughs of the castellations, therefore, are opposite one another, and together form the lightening holes.

The invention is particularly applicable to stiffening diaphragms in ship construction, wash-bulkheads, grain-bulkheads, bunker bulkheads, deep frames, hatch-webs, buttress-plates, webs of plate girders, webs of stanchions, and the like, and to similar construction in other branches of engineering.

Dated the 27th day of August, 1937.  
G. M. BOYD.

### PROVISIONAL SPECIFICATION No. 24182 A.D. 1937.

#### Improvements in Built-up Structural Members

I, GEOFFREY MURRAY BOYD, of 11, Burwood Avenue, Hayes, Kent, British, do hereby declare the nature of this invention to be as follows:—

This invention is concerned with built-up structural members, and has for its object the more economical production of compound beams, struts or tie members.

The invention is carried into effect by uniting together, preferably by welding, two or more pieces with castellated or serrated edges in such a way that the crests of the castellations on two adjacent pieces coincide, so that the troughs of the castellations united form openings or holes in the member.

The shape and pitch of the castellations are carefully chosen so that in cutting a piece of the material, for instance a steel joist or channel, in a zig-zag longitudinal

line, two pieces can be formed which may serve in making up improved built-up members.

In this way a castellated part of a steel joist may be united to a suitably castellated part of a steel channel; a castellated part of a plate to a castellated part of a joist, and so forth.

Compound members built up by this means may be further built up by the addition of angles, flats, plates, or other sections as required.

The invention is particularly applicable to structural steel, aluminium alloy structural members for aircraft, motor cars and the like, and to structural members of timber and other materials.

Dated this 4th day of September, 1937.  
G. M. BOYD.

### COMPLETE SPECIFICATION

#### Improvements in Built-up Structural Members

I, GEOFFREY MURRAY BOYD, of 11, Burwood Avenue, Hayes, Kent, a British subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to structural elements of the kind comprising two parts with pairs of projections extending towards one another and welded together at the end portions thereof to unite the said parts, each part being derived by the division of a plate of metal along a line of sinuous or toothed nature. In connec-

tion with such elements it has previously been proposed in order to avoid the necessity for specially constructed, cumbersome, expensive machinery in effecting the division, to punch or otherwise form the web of a channel beam with a series of equidistantly spaced openings disposed in a zig-zag line along the web, subsequently to shear the web along lines extending between adjacent openings, thus dividing the beam into two parts each including a number of angular projections and then to place the parts with the tips of the projections in contact and to weld together the points of the projections. This method

of division, however, entails a substantial amount of work in manipulating the beam, in forming the numbers of openings and in shearing the successive lengths of web between neighbouring openings and it is difficult or impossible to effect the division without deforming the web and therefore the projections, whilst considerable time and power are required to complete the operation. The connection of the two parts by welding merely at the points of the projections, moreover, imparts but little stiffness to the element. An object of the invention is to enable structural elements of the kind in question to be manufactured not only with simple apparatus but also cheaply and expeditiously in a manner facilitating the production of the most favourable forms of projection and of projections of any desired size. A further object of the invention is the provision of improved forms of structural elements of the type to which the invention relates.

The present invention includes the method of manufacturing a structural element of the kind specified, characterised by the step of dividing at least one metal member to form the two parts by the instrumentality of a cutting flame such as an oxy-acetylene flame.

Preferably, moreover, in carrying out the invention, after effecting the division I place the two parts with edges of the respective pairs of projections extending contiguously over lengths thereof and weld together the projections along the said lengths.

The invention further comprises effecting the division so that projections on the divided parts at opposite ends of a member respectively extend in opposite directions and are of equal width and so placing the two parts to be welded together that the projections at the extremities of the parts occur at one end of the element.

In one form of element in accordance with the invention the apertures between adjacent pairs of projections are of an hexagonal shape such that lines drawn through the centres of longitudinal welds on opposite sides of an aperture and parallel to the adjacent sides of the aperture on the same side of the line of welds intersect at a point lying within the boundaries of the element.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a side view of a rolled steel member of  $\Sigma$ -section;

Figure 2 is an end view of Figure 1;

Figures 3 and 4 are end views illustrative of members of other shapes which may be used in carrying out the invention;

Figure 5 is a side view of a structural

element formed from the member shown in Figures 1 and 2;

Figure 6 is a section on the line VI—VI of Figure 5;

Figures 7 and 8 are cross-sectional views of structural elements manufactured from members such as that shown in Figure 3;

Figures 9 and 10 are cross-sectional views of structural elements each manufactured from two members of different cross-sectional shape;

Figure 11 is a side view of a member cut to provide two tapering parts;

Figure 12 is a side view of a tapering structural element;

Figure 13 is a side view of a tapering hatch beam and Figure 14 shows a section on the line XIV—XIV of Figure 13;

Figure 15 shows somewhat diagrammatically in cross-section the double bottom of a ship;

Figures 16 and 17 are cross-sectional views of box girders in accordance with the invention;

Figures 18 and 19 are side views of flanged elements showing different shapes of aperture;

Figure 20 is an isometric view of a member manufactured from a rolled steel  $\Sigma$  joint and provided with reinforcing flanges and transverse members;

Figure 21 is an isometric view of a strut or stanchion and Figure 22 is a cross-section of Figure 21;

Figure 23 is an isometric view of a stanchion formed of two systems both comprising two flanged parts;

Figure 24 is a side view showing how a member may be divided along an axis offset from its longitudinal axis;

Figures 25 and 26 are side views of structural elements utilising parts formed by dividing members in the manner shown in Figure 24;

Whilst 27 is a side view showing how a member may be divided along a zig-zag line and;

Figure 28 shows a structural element formed from the parts of a member divided in the manner shown in Figure 27.

Referring now to Figures 1, 2, 5 and 6, a rolled steel  $\Sigma$  beam having flanges 1 and a web 2 is divided into two parts 3 and 4 by an oxy-acetylene flame which cuts along a sinuous line 5 symmetrically disposed in relation to the longitudinal axis 8 of the beam. In this manner a number of projections 10 are provided in the webs of the divided parts 3 and 4 and it will be observed that at the opposite ends of the beam the parts 3 and 4 respectively are formed with projections 6 and 7 of equal width and extending in opposite directions. The sinuous line at the corners 13

is curved to give rounded corners to the apertures in the completed element.

The parts 3 and 4 or one of these parts and a part of similar shape from another beam, are now placed side by side with the projections 10 in the same plane and with the projections 6 and 7 and pairs of projections 10 extending towards one another with apertures 12 between pairs of projections and the projections are welded together at the neutral axis 9, of the resulting element along the lines 11 at the junctions of the projections. The welding is effected in any suitable manner, for example, electrically or by an oxy-acetylene or other suitable flame.

It will be seen that there is provided a structural element consisting of two parts provided with plate like projections 10 and that the projections on one part are complementary to the parts of the apertures 12 in the other part.

The width of the completed element, its moment of inertia and its section modulus are considerably greater than those of the original beam and the load carrying capacity is much increased. This result is obtained by rearrangement of the two parts cut from the original beam or beams and without waste of material or adding to the weight of an original beam. Welding at or near the flanges 1 where the greatest stresses normally occur in practice is avoided and the length of weld is very moderate.

If desired a transverse strengthening plate may be provided at the end of the element remote from the projections 6 and 7 and stiffeners may be welded to the web 2. Such stiffeners may be in the form of plates or angle pieces extending between the flanges 1 parallel to the sides of the projections 10 and across the centres of the welds 11, or the stiffeners may extend across the apertures 12.

Figures 3 and 8 show how an element can be manufactured in a similar manner from a rolled steel channel member.

Figures 3 and 7 show how an element can be manufactured in a similar manner from a rolled steel channel member, with the exception that the parts 3 and 4 instead of being reversed relatively to one another are placed with the flanges 14 facing in the same direction. Since this involves a relative longitudinal movement through a distance equal to half the distance between the adjacent projections on one of the parts there will be a certain wastage at the ends of the parts. This difficulty can, however, be overcome by obtaining the two parts from two different channel members so cut that parts from the respective members are complementary to one another.

Figure 9 shows how parts 15 and 16 cut respectively from a channel member and an I beam in the manner previously described may be combined to provide an element having at one edge a single flange 17 and at the other edge a double flange 18.

Figure 10 shows how parts 17 and 18 cut respectively from a plate such as that shown in Figure 4 and an I beam in the manner previously described may be combined to provide an element of substantial depth having a double flange 19 at one edge only. If desired flanges 20 may be provided on the part 17 by welding or riveting.

Figures 11 and 12 illustrate a construction similar to that of Figures 1, 2, 5 and 6 with the exception that the member is divided along an axis 21 inclined to the longitudinal axis of the member to produce two parts which may be utilised in forming a tapered element as shown in Figure 12. Clearly, tapered elements having other cross-sections, for example, those shown in Figures 7, 8, 9 or 10 may be formed in accordance with the invention.

Figure 13 shows a hatch beam including a part 18 with a double flange 19 formed from an I beam and an upper part 17 including two portions 23 and 24 welded together at 25 and tapering from that weld at the centre of the hatch beam to the ends of the beam, the said portions 23 and 24 being formed by dividing a plate along an axis inclined to the longitudinal axis of the plate.

In Figure 15 the ship's hull includes the side members 26 connected with the double bottom comprising inner and outer shells 27 and 28 respectively spaced apart by a number of transverse plates 29, 29' and longitudinal plates 30 and 31.

Each of the plates 29, 29' and 31 is formed by dividing at least one steel plate member along an axis to provide two parts each with a plurality of similar projections 10 defined by the line of division, placing two parts 58 and 59 thus formed with the projections on the two parts extending towards one another and with end portions of the projections on one part respectively adjacent to end portions of the projections on the other part and uniting the parts by welding together adjacent projections at the junctions 11 therebetween. The plate 30 is solid and continuous.

It will be appreciated that the apertures 12 in the plates 29 and 31 are provided without or substantially without waste of material and that the necessity of handling heavier plates than are required is avoided. The design of the apertures 12, moreover, is not limited by the sizes of

punch available as is the case when the apertures are formed by a punching machine, whilst the length of cut is less than if the apertures 12 were formed by cutting parts from a plate. The apertures 12 may be of any suitable shape and the parts 58 and 59 may be divided from different plates and formed with spaces of different configurations between the projections.

Figure 16 shows how two elements 33 such as that illustrated in Figure 7 may be used to form a box girder by uniting adjacent pairs of flanges 14 of the two elements by plates 32. Access may be had to the interior of the girder through the apertures in the side members 33 and the plates 32 may be united with the flanges 14 by welding along the inner edges 35 of the flanges 14 and along the angles 34 at the junctures of the plates 32 and the outer surfaces of the elements 33.

Figure 17 shows how two elements 36 such as that illustrated in Figures 5 and 6 may be used to form a box girder by uniting adjacent pairs of flanges 1 of the two elements by plates 32, for example, by welding the parts together at 37 and 38.

If desired suitable strengthening members may be welded within the box girder shown in Figure 16 or Figure 17.

Figure 18 illustrates a preferred shape of aperture which may be used, for example, in the element shown in Figures 5 and 6 or in Figure 7, 8, 9, or 10 of the drawings. As shown, the apertures 12 are of hexagonal shape and the angles 39 of the apertures at the welds are not greater than  $90^\circ$ , whilst the lengths of the sides 40 of the apertures parallel to the flanges are equal to one quarter of the width of a flanged metal member such as that shown in Figure 1 of the drawings and the element has a width 50% greater than that of the said member.

It will be seen that lines drawn through the centres of the longitudinal welds 11 on opposite sides of an aperture 12 and parallel to the adjacent sides 41 or 42 of the aperture on the same side of the line of welds intersect at a point lying near the boundaries of the element. It may be preferred to dimension the parts so that the intersection actually falls within the boundaries of the element. As previously mentioned the corners 13 are rounded.

Figure 19 illustrates an alternative shape of aperture in which the sides 40 of the apertures are again equal to one quarter of the width of a flanged metal member such as that shown in Figure 1 of the drawings, but in which the welds 11 are brought closer together by increasing the angle 39 to  $120^\circ$  or there-

abouts.

In Figure 20 an element such as that shown in Figures 5 and 6 of the drawings is provided with flange plates 43 and 44 welded to the flanges 1 by intermittent or continuous fillet welds 45. At the end of the girder at which the web overhangs, moreover, a plate 47 is welded between the overhanging parts 50 of the web, whilst at the ends of the girder plates 46 and 48 perpendicular to the flanges 1 are welded to the web 2 and between the ends of the girder, strut stiffeners in the form of plates 49 are disposed across the centres of the welds 11 and parallel to sides of the apertures 12 and are also welded by intermittent or continuous welds to the web 2.

It will be appreciated that the flanges 1 give transverse rigidity while the plates 43 and 44 are being welded in position. Additional resistance to shear is imparted to the girder by the plates welded to the web.

The structural element shown in Figures 21 and 22 comprises four flanged parts 51, 52, 53 and 54 each of which includes a series of projections 10 formed by dividing the web of a rolled steel flanged member along a line of a sinuous or toothed nature, the said projections extending inwardly from the flanges 1 of the parts 51, 52, 53 and 54 equiangularly around and towards a longitudinal axis and being welded together.

The welds 55 between the projections 10 of the diametrically opposite parts 52 and 54 are somewhat to one side of the axial centre line of the element. This result may be achieved by dividing an I beam along an axis somewhat offset from the longitudinal axis of the beam. The projections 10 of the other two diametrically opposite parts 51 and 53 are respectively welded by welds 56 at the axial centre line of the element to opposite sides of the projections 10 of the part 54. If desired struts 57 extending between and welded to adjacent projections 10 may be provided.

Instead of four flanged parts, a structural element may comprise three flanged parts or more than four flanged parts, the projections of the said parts extending inwardly from the flanges of the parts, equiangularly around and towards a longitudinal axis and being welded together.

The modified form of structural element shown in Figure 23 is formed of two systems 60 and 61, comprising respectively the pairs of flanged parts 64, 65 and 62, 63. Each flanged part includes a series of plate like projections 10 and the respective projections 10 of the parts 62, 130

64, 63 and 65 extend inwardly from the flanges 1 of the parts equiangularly around and towards a longitudinal axis. Thus pairs of projections on the parts 62 and 63 and on the parts 64 and 65 extend towards one another and these sets of adjacent projections are welded together along the lines 11. As shown, there are apertures 12 between the adjacent sets of projections of each system and the sets of projections of one system extend through the apertures of the other system. The systems 60 and 61 are connected, for example, by struts 66, which are shown as being welded to the flanges 1. Alternatively they may be welded to the projections.

The systems may be formed of more than two flanged parts. For example, each system may comprise three flanged parts, in which case these will be six series of plate like projections extending inwardly from the six flanges equiangularly around and towards a longitudinal axis and sets of three projections of one system will extend through apertures between adjacent sets of three projections of the other system.

Mention has been made of dividing an I-beam along an axis offset from its longitudinal axis. It will be appreciated that by dividing a plurality of members along axes offset from the longitudinal axes thereof and utilising two parts of greater width thus formed, a structural element may be produced of greater depth than if similar lines of division had been made about the longitudinal axes of the members. Two parts of smaller width thus formed may be utilised in the formation of a structural element of smaller depth.

Figure 24, for example, shows an I-beam divided along a sinuous line 5 symmetrically disposed in relation to an axis 66 offset with respect to the longitudinal axis 8 of the beam. In this manner there are formed a part 3 of greater width and a part 4 of smaller width. Figure 25 shows how two parts 3 are utilised in forming an element of greater depth than would be obtained had the I-beam been divided along its longitudinal axis. Figure 26 shows how the parts 4 may be utilised in forming an element of relatively small depth.

It will be appreciated that the line of division of a member need not be symmetrical about the axis of division. The line of division, moreover, may be of various shapes. Thus, for example, in Figure 27 the line of division 5 is of zig-zag form so that the projections on the parts 3 and 4 are of triangular shape and extend to tips 67 and 68. As shown in

Figure 28 the sides of the end portions 67 and 68 of pairs of the teeth resulting from the division are welded together over lengths thereof. The apertures 12 in this construction are shaped as parallelograms.

The invention is useful in many different fields of engineering and apart from stiffening diaphragms in ship construction, hatch-webs, webs of plate girders and webs of stanchions may, for example, be applied to wash grain or bunker bulkheads, deep frames, buttress plates or to aluminium alloy structural elements for air craft, motor cars or the like.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. The method of manufacturing a structural element of the kind specified, characterised by the step of dividing at least one metal member to form the two parts by the instrumentality of a cutting flame such as an oxy-acetylene flame.

2. The method of manufacturing a structural element as claimed in claim 1, characterised by the step of placing the two parts with edges of the respective pairs of projections extending contiguously over lengths thereof and welding together the projections along the said lengths.

3. The method of manufacturing a structural element as claimed in claim 1 or claim 2, characterised by the step of dividing two members which are of different cross-sectional shape and at least one of which is flanged at its edges to provide from each member two parts each with a series of projections so spaced that the pitch of the projections on a part of one member corresponds to the pitch of the projections on a part of the other member, and utilising one part from the one member and one part from the other member in the formation of the structural element.

4. The method of manufacturing a structural element as claimed in any preceding claim, characterised by the step of effecting the division so that projections on the divided parts at opposite ends of a member respectively extend in opposite directions and are of equal width and so placing the two parts to be welded together that the projections at the extremities of the parts occur at one end of the element.

5. The method of manufacturing a structural element as claimed in any preceding claim characterised by dividing a member along an axis inclined to the

longitudinal axis of the member and thereby forming parts of tapered shape.

6. The method of manufacturing a structural element as claimed in claim 1, claim 2 or claim 3, characterised by dividing a plurality of members along axes offset from the longitudinal axes thereof and utilising two parts of greater width thus formed in the production of the structural element.

7. A structural element manufactured in accordance with any one of the preceding claims.

8. A structural element as claimed in claim 7, characterised in that apertures between adjacent pairs of projections are of an hexagonal shape such that lines drawn through the centres of longitudinal welds on opposite sides of an aperture and parallel to the adjacent sides of the aperture on the same side of the line of welds intersect at a point lying adjacent to or within the boundaries of the element.

9. A structural element manufactured in accordance with claim 1 or claim 2 and flanged at its edges, characterised in that apertures between adjacent pairs of projections are of such hexagonal shape that the angles of the apertures at the welds are not greater than  $90^\circ$ , whilst the lengths of the sides of the apertures parallel to the flanges are equal to one quarter of the width of a flanged metal member, the element having a width 50% greater than that of the said member.

10. A structural element as claimed in claim 7 formed from a flanged member or flanged members, characterised in that plates are united with the flanges by welding together the plates and flanges along the edges of the flanges.

11. A structural element as claimed in claim 7 or claim 10, formed of a flanged member or flanged members, characterised in that transverse stiffeners are welded to the web connecting the flanges.

12. A box girder characterised by plates uniting adjacent flanges of two adjacent, parallel flanged structural elements as claimed in claim 7 and formed of a flanged member or flanged members.

13. A structural element as claimed in claim 7, characterised by at least three flanged parts each of which includes a series of projections formed by dividing the web of a flanged metal member along a line of a sinuous or toothed nature, the said projections of the respective parts extending inwardly from the flanges, equiangularly around and towards a longitudinal axis and being welded together.

14. A structural element as claimed in claim 13, characterised in that there are

four flanged parts and the welds between the pairs of projections of two diametrically opposite parts are somewhat to one side of the axial centre line of the element, whilst the projections of the other two diametrically opposite parts are respectively welded at the axial centre line of the element to opposite sides of projections of one of the parts of the first mentioned diametrically opposite parts.

15. A structural element as claimed in claim 7, characterised by the provision of two systems both comprising at least two flanged parts each of which includes a series of plate like projections, the said projections of the respective parts extending inwardly from the flanges equiangularly around and towards a longitudinal axis, and welds connecting together sets of adjacent projections of each system, there being apertures between adjacent sets of projections of each system, whilst sets of projections of one system extend through the apertures of the other system and the systems are connected together, for example, by struts.

16. A structural element manufactured in accordance with claim 1 or claim 2, in the form of an apertured diaphragm.

17. Structural elements manufactured in accordance with claim 1 and formed from rolled steel flanged sections substantially as hereinbefore described with reference to Figures 5 and 6 or any one of Figures 7, 8, 9, 12, 16, 17, 18, 19, 20, 25 and 28 of the accompanying drawings.

18. Structural elements manufactured in accordance with claim 1 and formed from rolled steel flanged sections and plates substantially as hereinbefore described with reference to Figure 10 or Figures 13 and 14 of the accompanying drawings.

19. Apertured diaphragms manufactured in accordance with claim 1 and substantially as hereinbefore described with reference to Figure 15 of the accompanying drawings.

20. A structural element manufactured in accordance with claim 1 and substantially as hereinbefore described with reference to Figures 21 and 22 of the accompanying drawings.

21. A structural element manufactured in accordance with claim 1 and substantially as hereinbefore described with reference to Figure 23 of the accompanying drawings.

Dated this 16th day of March, 1938.

For the Applicant,

A. C. PRICE,  
Chartered Patent Agent.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1.

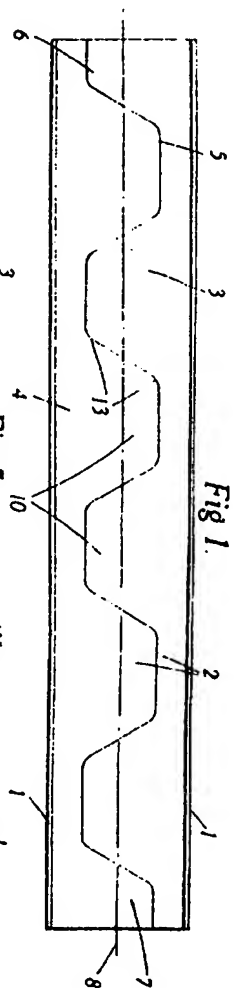


Fig. 5.

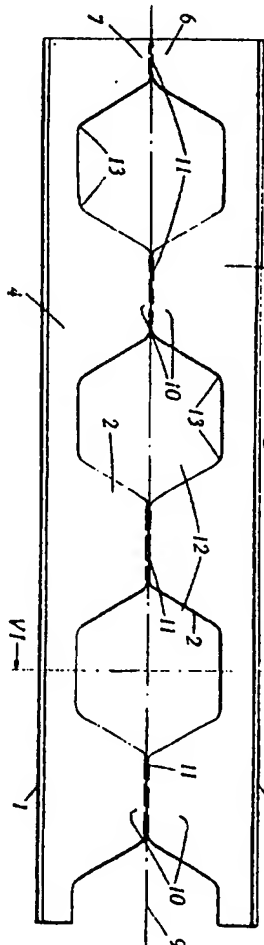


Fig. 11.

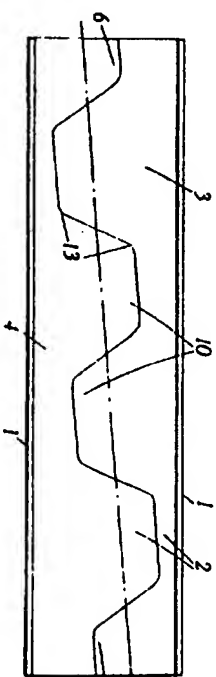


Fig. 13.

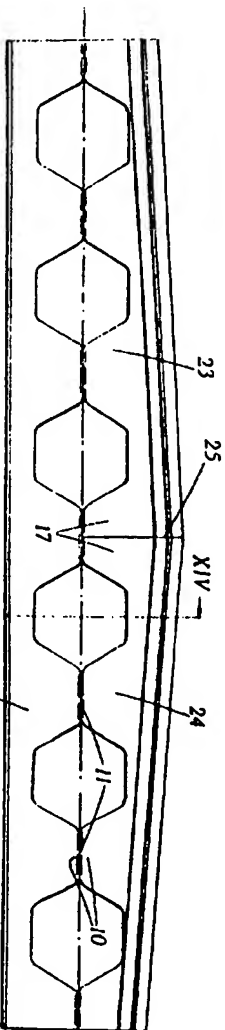


Fig. 14.

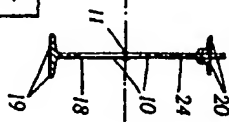


Fig. 15.

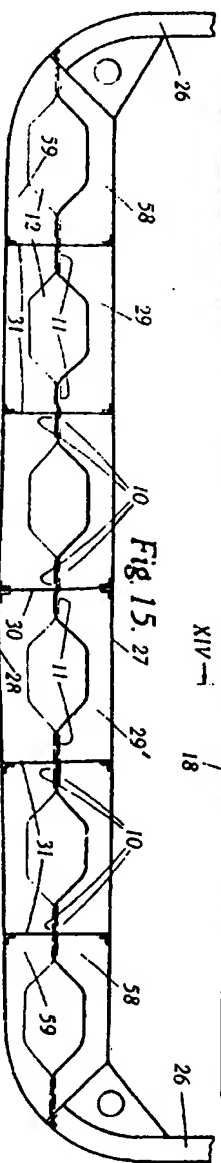


Fig. 2.

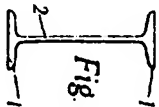


Fig. 3.

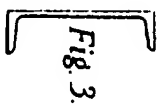


Fig. 4.

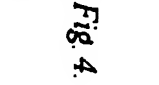


Fig. 6.

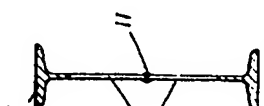


Fig. 7.

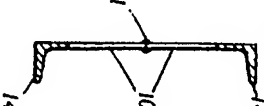


Fig. 8.

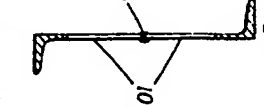


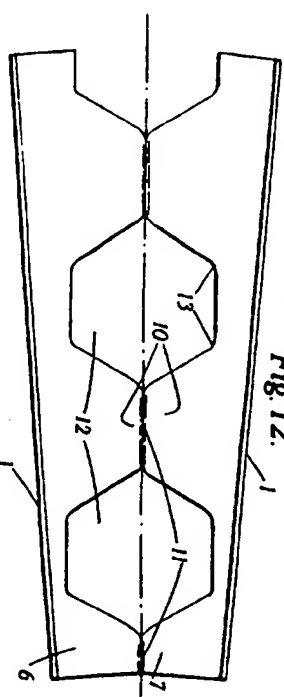
Fig. 9.



Fig. 10.



Fig. 12.



[This Drawing is a reproduction of the Original on a reduced scale.]

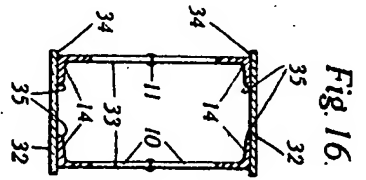


Fig. 16.

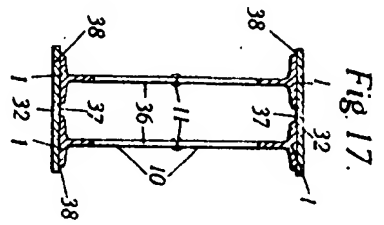


Fig. 17.

Fig. 18.

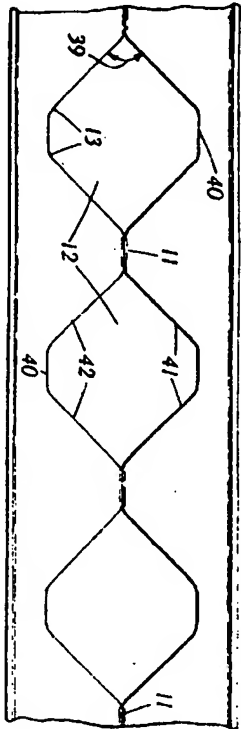


Fig. 19.

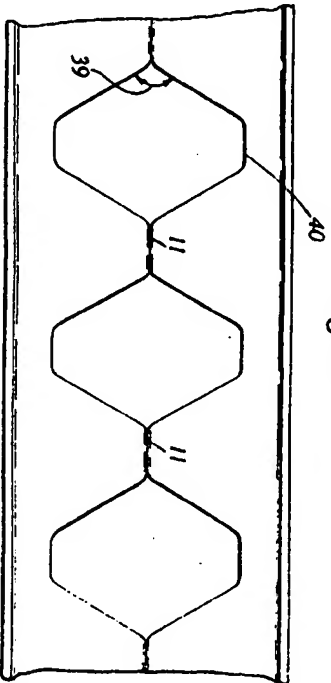


Fig. 20.

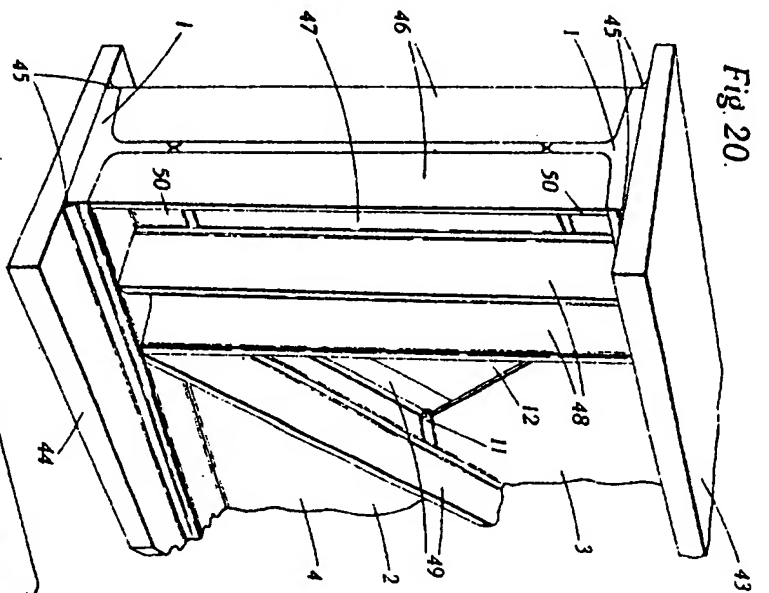


Fig. 21.

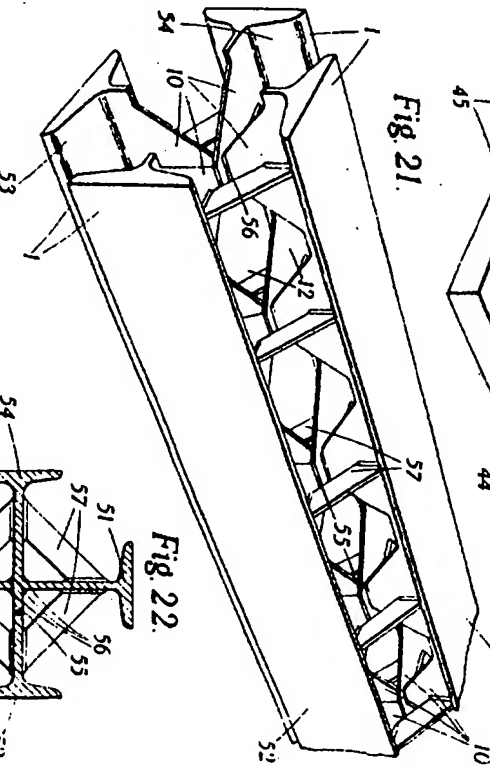
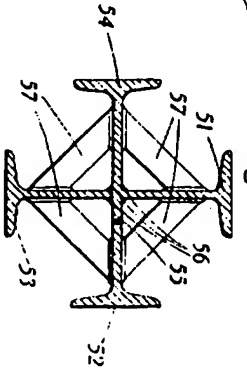


Fig. 22.



[This Drawing is a reproduction of the Original on a reduced scale.]

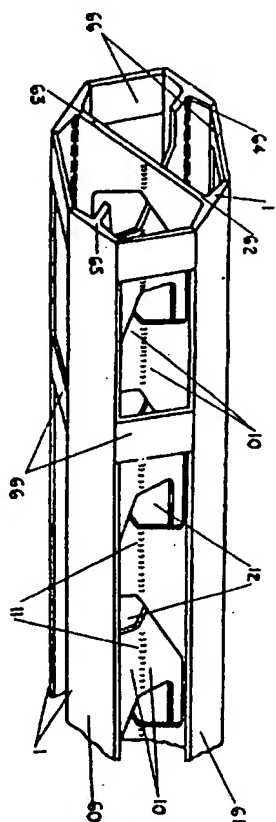


FIG. 23.

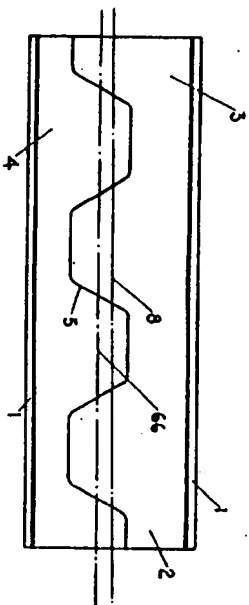


FIG. 24.

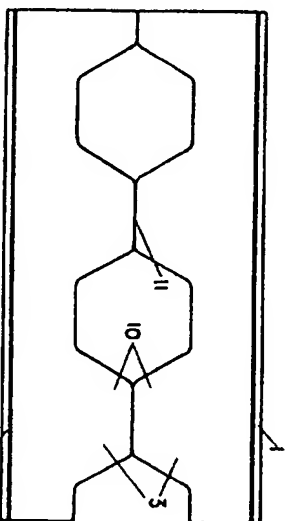


FIG. 25.

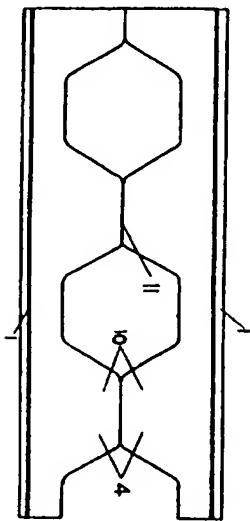


FIG. 26.

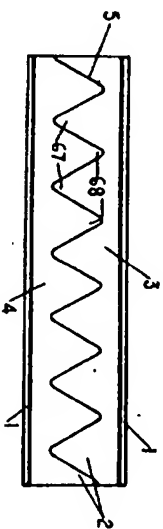


FIG. 27.

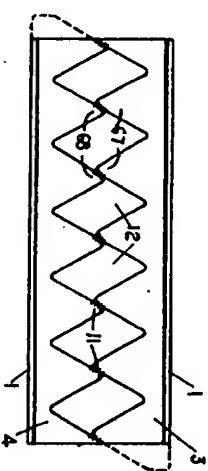


FIG. 28.